MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 3, 2018 / 2019

PPH0125 - MECHANICS
(Foundation in Engineering)

28 MAY 2019
2.30 p.m. – 4.30 p.m.
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of **FOUR** printed pages, excluding the cover page and appendices, with **FIVE** questions.
2. Answer all questions. The distribution of the marks for each question is given.
3. Write all your answers in the answer booklet provided.
4. All necessary workings must be shown.

QUESTION 1 (10 marks)

a) If **P** = 3**i** – 4**j** and Q = 5**i** – 6**k**, find the dot product of **P** and **Q**.

(2 marks)

b) A car covers 50.0 m in 6.50 s while uniformly slowing down to a final velocity of 3.2 m/s. Find

i. the initial speed of the car.

(1 mark)

ii. the acceleration of the car.

(1 mark)

c) A block of mass 1.5 kg moves with a constant speed of 3.0 m/s on a smooth horizontal surface under the action of a force F as shown in **Figure Q1.1**. Calculate the normal force acting on the block.

(2 marks)

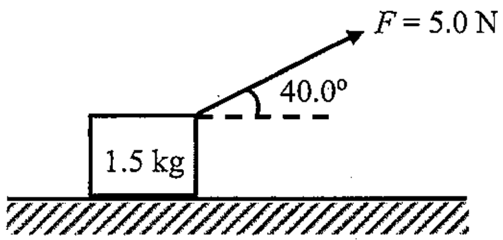

Figure Q1.1

d) A 100.0-N force is applied to a socket wrench as shown in **Figure Q1.2**. If the magnitude of the torque due to the force is 60.0 N m, calculate the length L.

(2 marks)

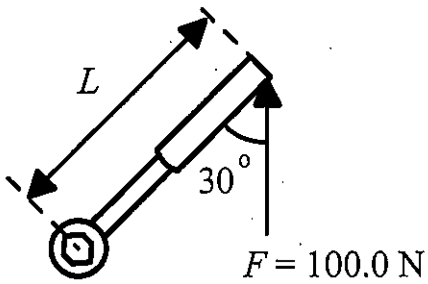

Figure Q1.2

e) A block of mass 12.0 kg is pulled with a constant speed by a horizontal force across a rough horizontal surface for a distance of 7.5 m. If the coefficient of friction between the surface and the block is 0.4, find the work done by the horizontal force.

(2 marks)

Continued...

QUESTION 2 (10 marks)

a) A 50.0-cm diameter disk rotates with a constant angular acceleration of 3.2 rad/s^2. It starts from rest at orientation shown in **Figure Q2.1** where *OP* is a dashed line drawn from the centre to a point *P*, on the rim of the disc. At $t = 2.5$ s, find

i. the angular speed of the wheel at *P*.

(1 mark)

ii. the linear velocity and tangential acceleration of *P*.

(2 marks)

iii. the position of *P* (in degrees, with respect to +*x*-axis).

(3 marks)

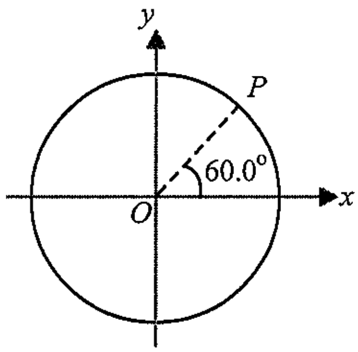

Figure Q2.1

b) **Figure Q2.2** shows the initial positions of two masses, $m_1 = 21.0$ kg and $m_2 = 32.0$ kg, connected by a rope that hangs over a pulley. The pulley has a diameter of 0.6 m and moment of inertia of 0.2 kg m^2. If the pulley rotates without slipping and the system is released from rest, use conservation of energy to find the speed of m_2 before it hits the ground.

(4 marks)

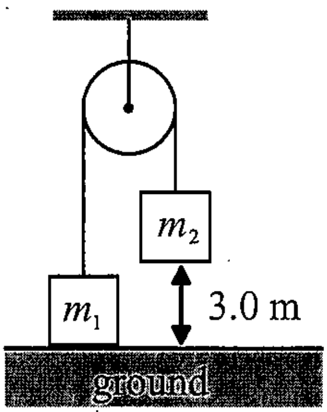

Figure Q2.2

Continued...

QUESTION 3 (10 marks)

a) Three identical masses ($m_1 = m_2 = m_3$) are placed on the vertices of an isosceles triangle as shown in **Figure Q3.1**. If the magnitude of net gravitational force acting on m_1 is 5.6×10^{-6} N, find the value of the masses.

(4 marks)

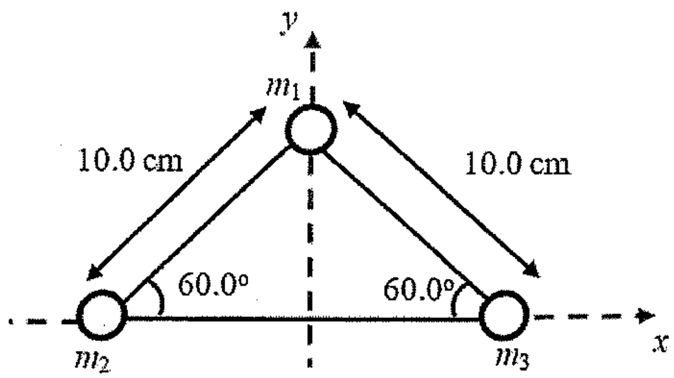

Figure Q3.1

b) A satellite has a mass of 120.0 kg and is located at 2.5×10^6 m above the surface of the Earth.

i. What is the magnitude of the gravitational force on the satellite?

(2 marks)

ii. Calculate the period of the orbit. Write your answer in hours.

(2 marks)

iii. Find the tangential speed of the satellite.

(1 mark)

iv. Calculate the centripetal acceleration of the satellite.

(1 mark)

QUESTION 4 (10 marks)

a) A vertical spring elongates by 14.0 cm when a mass of 2.5 kg is hung from its end. How much more will it elongate if an additional 1.0 kg is attached to the first mass?

(2 marks)

b) A 70.0-cm long metal rod with a radius of 0.2 mm elongates by 0.6 mm when a mass of 4.0 kg is suspended from its end.

i. What is the stress in the rod?

(2 marks)

ii. Find the strain on the rod

(1 mark)

Continued...

c) A large balloon of mass 220.0 kg is filled with helium gas until its volume is 330.0 m^3. Assume the density of air is 1.29 kg/m^3 and the density of helium is 0.18 kg/m^3.

   i. Draw the free body diagram for the balloon. (There are three forces act on the balloon)

   (1.5 marks)

   ii. Calculate the buoyant force acting on the balloon.

   (1.5 marks)

   iii. Find the net force on the balloon.

   (2 marks)

QUESTION 5 (10 marks)

a) An object oscillates in simple harmonic motion (*SHM*) according to equation

$$x = 8.0 \cos (1.2\, t + 0.4)$$

where each term is in SI units. Find

   i. the amplitude.

   (1 mark)

   ii. the frequency.

   (1 mark)

   iii. the initial phase at $t = 0$.

   (1 mark)

   iv. displacement at $t = 2.0$ s.

   (2 marks)

b) A 2.00-kg frictionless block is attached to a spring with a spring constant of 300 N/m. At $t = 0$ the spring is at its original length and the block is moving to the left with a speed of 12.0 m/s.

   i. What is the amplitude of the motion?

   (2 marks)

   ii. Write the equation representing the position of the block as a function of time.

   (3 marks)

End of page

APPENDIX I

Physical Constants

Quantity	Symbol	Value
Electron mass	m_e	9.11×10^{-31} kg
Proton mass,	m_p	1.67×10^{-27} kg
Elementary charge	e	1.602×10^{-19} C
Gravitational constant	G	6.67×10^{-11} N.m^2 /kg^2
Gas constant	R	8.314 J/K.mol
Hydrogen ground state	E_o	-13.6 eV
Boltzmann's constant	k_B	1.38×10^{-23} J/K
Compton wavelength	λ_c	2.426×10^{-12} m
Planck's constant	h	6.626×10^{-34} J.s
Speed of light in vacuum	c	3.0×10^{8} m/s
Rydberg constant	R_H	1.097×10^{7} m^{-1}
Acceleration due to gravity,	g	9.8 m /s^2
Atomic mass unit (1u)	u	1.66×10^{-27} kg
Avogadro's number	N_A	6.023×10^{23} mol^{-1}
Threshold of intensity of hearing	I_o	1.0×10^{-12} W /m^2
Coulomb constant	k	9.0×10^{9} N m^2 /C^2
Permittivity of free space	ϵ_o/κ_o	8.85×10^{-12} C^2/N.m^2
Permeability of free space	μ_o	$4\pi \times 10^{-7}$ H/m

<u>Energy equivalent of atomic mass unit:</u>

One atomic mass unit (1.0 u) is equivalent to 931.5 MeV

Earth:

Gravity	=	9.8 m/s^2
Radius	=	6.4×10^6 m
Mass	=	6.0×10^{24} kg

Moon:

Mass	=	7.4×10^{22} kg
Radius	=	1.7×10^6 m

Sun:

Mass	=	2.0×10^{30} kg
Radius	=	7.0×10^8 m

Mean distance from:

Sun to Earth	=	1.5×10^{11} m
Moon to Earth	=	3.9×10^{8} m

APPENDIX II

List of formulas

$y = kx^n$ $\frac{dy}{dx} = knx^{n-1}$	$\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$ $\cos\theta = \frac{\text{adjacent}}{\text{hypotenuse}}$ $\tan\theta = \frac{\text{opposite}}{\text{adjacent}}$ $\sin\alpha + \sin\beta = 2\cos\left(\frac{\alpha-\beta}{2}\right)\sin\left(\frac{\alpha+\beta}{2}\right)$ $\sin(\alpha-\beta) + \sin(\alpha+\beta) = 2\sin\alpha\cos\beta$

$v = v_o + gt$ $\quad y - y_o = v_o t + \frac{1}{2}gt^2$ $\quad v^2 = v_o^2 + 2g(y - y_o)$

$y - y_o = \left(\frac{v_o + v}{2}\right)t$

$a_c = \frac{v^2}{r}$ $\quad F_g = G\frac{m_1 m_2}{r^2}$ $\quad U_g = -G\frac{m_1 m_2}{r}$ $\quad T^2 = K_s r^3$

$\tau = r \times F$ $\quad \sum\tau = \tau_{net} = I\alpha$ $\quad I = \sum mr^2$

$v = r\omega$

$L = r \times p = I\omega$ $\quad K = \frac{1}{2}I\omega^2$ $\quad |\tau| = |r||F|\sin\theta$

$T_s = 2\pi\sqrt{\frac{m}{k}}$ $\quad T_p = 2\pi\sqrt{\frac{l}{g}}$ $\quad T = \frac{2\pi}{\omega} = \frac{1}{f}$ $\quad \bar{y} = \frac{\sum_{i=1}^{N} m_i y_i}{\sum_{i=1}^{N} m_i}$

$x = A\cos\omega t$ $\quad x = A\sin\omega t$

$v = -\omega A\sin\omega t$ $\quad v = \omega A\cos\omega t$ $\quad W_F = |r||F|\cos\theta$

$a = -\omega^2 A\cos\omega t$ $\quad a = -\omega^2 A\sin\omega t$

$v = \frac{\Delta x}{\Delta t}$ $\quad a = \frac{\Delta v}{\Delta t}$

$v = v_o + at$ $\quad x - x_o = v_o t + \frac{1}{2}at^2$ $\quad v^2 = v_o^2 + 2a(x - x_o)$ $\quad x - x_o = \left(\frac{v_o + v}{2}\right)t$

$W = mg$ $\quad \sum F = F_{net} = ma$ $\quad f_s \le \mu_S F_N$ $\quad f_k = \mu_K F_N$

$p = mv$ $\quad \sum F = \frac{\Delta p}{\Delta t}$ $\quad \Sigma W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ $\quad m_1u_1 + m_2u_2 = (m_1 + m_2)\,v$ $\quad P = \frac{W}{t} = \frac{E}{t} = \frac{Fd}{t} = F\bar{v}$

$K = \frac{1}{2}mv^2$ $\quad PE_s = \frac{1}{2}kx^2$ $\quad F_s = -kx$ $\quad PE_G = mgy$

$\bar{x} = \frac{\sum_{i=1}^{N} m_i x_i}{\sum_{i=1}^{N} m_i}$ $\quad W_{Fs} = \frac{1}{2}kx_i^2 - \frac{1}{2}kx_f^2$